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RDB PROJECT CARD

TYPE OF REPORT: New Project

REPORTS CONTROL SYMBOL: DD-RDB(AM)8

1. PROJECT TITLE (UNCLASSIFIED TITLE)
Geophysical Environment Data for ARS, WS117L
Short Title: ARS Environment

2. SECURITY: SECRET

3. PROJECT NUMBER: 1764

4. INDEX NUMBER: 2-117L

5. REPORT DATE: 2 April 1957

6. BASIC FIELD OR SUBJECT: Strategic Air Warfare System 117L

7. SUBFIELD OR SUBJECT SUBGROUP: Atmospheric Physics - 7B Physics

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8. COGNIZANT AGENCY: ARDC

9. DIRECTING AGENCY: GRD, AFCRC

OFFICE SYMBOL: CRZA

TELEPHONE NO.: HE 2-7730 X-9

10. REQUESTING AGENCY: HQ, USAF

11. PARTICIPATION, COORDINATION, INTEREST

USAF	USN
AMC-P ATIC-I	CNO-I
SAC-I	USA
ADC-I	C/S-I
APGC-I	Other
ATC-I	CIA-I

12. CONTRACTOR AND/OR LABORATORY: Geophysics Research Directorate

See 21c

CONTRACT/W.O. NO.: See 21C

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13. RELATED PROJECTS: WS

14. DATE APPROVED:

15. PRIORITY: 1A

16. A(Missiles)

17. EST. COMPL. DATES

RES.	1957
DEV.	1958
TEST	1959
OP. EVAL	

18. FY / FISCAL ESTS. (M $)

FY	
FY57	422M
FY58	1000M
FY59	1410M
FY60	425M
Total	3417M

19. This is the initial report on this project

20. REQUIREMENT AND/OR JUSTIFICATION

System Requirement No. 5 dated 17 October 1955 and subsequent letter directive from WDD dated 23 December 1955 assigned to AFCRC the responsibility for providing environmental data which affect the design and testing of ARS vehicles. Based on independent studies by the Geophysic Research Directorate the three design study contractors and conferences with personnel of the WSPO, it was concluded that in four areas of geophysical environment insufficient data were available for successful design and test of the Advanced Reconnaissance System Vehicles. The four so considered are (a) Meteor Physics (b) Density at Orbital Altitudes, (c) Solar Radiation in the U.V. and X-ray Region and (d) Thermal Radiation. Specific discussions of requirements for additional design data in each of these areas are included under each task.

21 a. Brief and Military Characteristics

The objective of this project is to provide environmental data considered essential to insure and simplify the design of a successful Advanced Reconnaissance System.

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22. RDB [redacted] IC & P. | X. | 1. | C.

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21 b. Approach

See individual Tasks. (21c)

21 c. Tasks

1. (a) T-39791 - Solar Radiation Program in Ultraviolet and X-ray Region for ARS

(b) This task will be accomplished through a combination of "in-house" and contractual effort. Currently the contractual effort is by Comstock and Westcott, Inc., under Contract AF 19(604)-1889. Other contractors contemplated at the moment are: University of Chicago, Chicago, Ill. and Radio Corporation of America, New York, N. Y.

(c) Task objective is to determine the intensity of Solar U.V. and Soft X-ray radiation as it would strike the satellite and the extent of damage due to collisions of molecules, atoms and ions with the satellite surface.

Requirement and/or Justification

Vehicle design will be affected by radiation in the solar ultraviolet and X-ray region. It has been shown by GRD that the quantum yield of photoelectric effect on metals exposed to short wavelength ultraviolet is about 250 times as great as that of the conventional photoelectric effect in the visible an near UV. Thus, since a vehicle traveling at 500 km is essentially receiving unfiltered solar radiation of low wavelength, one must consider a possible "charging-up" of the metal due to the loss of photoelectrons from the surface. This charge can theoretically rise to a high voltage, depending on the wavelength and intensity distribution of the incident radiation. Such a charging-up could influence the telemetering or other electronic functions of the equipment in the vehicle. Also, it is known that short wavelength ultraviolet causes deterioration of a plastic surface. This could fog plexiglass and damage rubber-like materials. Present data are inadequate to evaluate this effect simply because we do not know within several factors of ten the solar intensity above the atmosphere at wavelengths below 1500 Angstrom Units and we believe that design purposes can therefore not be satisfied.

The effect of atmospheric composition at 500 km is difficult to assess. There might be heating of the vehicle to contend with, due to recombination of atoms on the surface as well as impacts with other atoms and molecules. Such a heating effect would be super-imposed on that due to solar radiation and would act even at night when the vehicle is shielded from the sun by the earth. Since solar ultraviolet and X-ray radiation is part of the total picture of the integrated interaction of the sun and the earth's atmosphere and data of this kind are extremely scarce the measurements of these variables at vehicle altitude would be unique. These measurements would give us information as to the physical mechanisms operating in the ionosphere and delimit in an essential fashion the ionospheric functioning by giving us a better understanding of the nature of atmospheric ionization. This would assist in the forecasting of ionospheric propagation and could contribute toward the solution of the satellite communications problem.

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(d) Approach

At the present time, there are two main areas of research:

(1) A laboratory investigation of the effect of collisions of particles, atoms, molecules and ions on solid surfaces (sputtering) conjoined wit the effect of recombination of atomic species on solid surfaces.

This laboratory study will be carried on mainly in-house, but with modest contract let for auxiliary studies.

Primary in this research will be the problem of developing ultra high vacuum mass spectrometer tubes for study of the effect of ion bombardment of surfaces. Such a tube would require suitable component parts, valve sealants, tubing and pumps to obtain this vacuum. This is necessary to duplicate in the laboratory pressures at satellite altitudes. The feasibility of this development has already been established by in-house work. About half of this is finished, leaving principally design engineering.

Different techniques, among them molecular beams, will be used for the acceleration of the non-charged particles on receiving test plates the nature of which will be determined by vehicle design. In particular, the effect on metals will be examined. The plates will be tested by a variety techniques, microscopes, etc., for possible damage due to momentum transport (sputtering).

(2) Solar ultraviolet and X-ray study -- The goal set in this research is the measurement of absolute intensities of the solar spectrum from 1500 Angstroms down to a few Angstroms. This program is divided into three phases, laboratory investigations, measurements of solar intensities in rockets and finally, construction of the satellite instrumentation by miniaturization of rocket instrumentation.

This region of the spectrum is relatively unexplored; hence, a whole new system of monochromators, sources and detectors must be constructed. First, there must be the calibration against a primary detector, thermocouple not calorimetric. These secondary detectors must be reliable and reproducible. In type, they may be dependent upon the interaction of radiation with a filling gas or on the effect of radiation upon a cathode. Therefore, laboratory work will be needed to select adequate detectors.

The monochromators to be constructed are unique in design and rather elaborate in the equipment necessary to perform the desired calibration. They have already been designed and are presently under construction. To put them into actual operation will take an extensive period of working-out of the manifold details and problems involved.

The construction of detectors will be to a large extent under contract.

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Because the interaction of matter with radiation in this region is as yet little understood, the objectives can only be reached by an extensive deepening of our insights into the nature of these processes. For example, a predicted phenomenon is that of photoconductivity effect. This, when more fully investigated, may yield a possible secondary type of detector.

The process of building suitable detectors can only go on simulateneously with this type of exploratory research. After the laboratory phase, the instruments will be flown in Aerobee-Hi rockets to measure the radiation intensity above the earth's atmosphere. The number of flights necessary will be at least six, possibly increasing to eight or nine depending on results.

2. (a) T-39792 Interplanetary Matter and Meteor Physics in Relation to ARS

(b) This task will be accomplished through a combination of "in-house" and contractual effort. Currently the following contracts are in effect:

(1) - AF 19(604)-1894 - Temple University
(2) - AF 19(604)-1908 - Oklahoma A and M
(3) - AF 19(604)-1901 - Smithsonian Observatory
(4) - AF 19(604)-1892 - Stanford Research Inst.

No other contracts are contemplated at the moment.

(c) The objective of this task is to determine the possible hazard from meteoric bombardments to a vehicle above the earth's atmosphere and to provide data as to the spatial distribution, size, composition, and velocity of micrometeoric matter.

Requirement and/or Justification

The hazard from meteoric collision with a body essentially in interplanetary space, unprotected by the earth's atmosphere is not very well known. The probability of collisions intense enough to destroy the vehicle or affect its operation is very important in the design of a protective "meteor bumper" to insure proper operation of the vehicle. These meteoric collisions may result in dangerous surface erosions affecting heat exchange properties and optical windows. Stability, temperature control, reliability may all be influenced by meteoric bombardment.

Information regarding the influx of meteoric material into the earth's atmosphere has been collected by the following methods: visual observations, photography, radio reflections from meteor trails, and telescopic observations. From such studies and measurements, the diurnal and seasonal variations in the influx of sporadic meteors, velocities and radiants of shower meteors, velocity distribution of sporadic meteors, mass distribution of meteors, and spatial density of meteors have been determined. These measurements give a value for the rate of influx of interplanetary material into the earth's

atmosphere of 5×10^6 gm per day. However, these ground-based methods are limited and a grave anomaly, of importance to the ARS, exists. Since the visual and photographic methods are only sensitive to meteors of visual magnitude +5 (10^{-2} grams mass, 10^{11} ergs energy) and the radio and telescope methods to visual magnitude of the order of +8 (mass x 10^{-4} gm, energy 6×10^9 ergs), information derived from these methods regarding meteoric particles with mass less than 10^{-4} gm is seriously lacking. These smaller particles are far more numerous and therefore have a high probability of encountering a vehicle above the earth's atmosphere.

The anomaly on the influx of interplanetary matter arises from various indirect measurements of the fine interplanetary matter. These measurements include determination of the density of matter in the zodiacal cloud, or the interplanetary dust cloud, by S. C. Van de Hulst and C. W. Allen; measurements of the nickel content in deep sea ocean sediments by H. Pettersson and H. Rotsch; and initial rocket soundings from V-2 and Aerobee rockets. These measurements indicate a rate of accretion of interplanetary matter by the earth as high as 5×10^{10} gm per day, up to a factor of 10^4 times higher than predicted from regular methods of observation. It seems, also, that this high rate of influx may be necessary to explain the presence of the E region ionization during the night. This higher rate leads to a probably encounter for visual magnitude 15 (energy 10^{10} Bev) of one hit per square meter per second. Such impact rates are significant for a vehicle with a required lifetime of about a year. These impact rates may possibly be further increased by a factor as great as 10^4 to 10^6 if geomagnetic focusing of cosmic dust particles, suggested also by S. F. Singer, was detected experimentally.

From the standpoint of ARS, the hazard to space vehicles in an interplanetary environment seems closely dependent upon the effects of interplanetary matter, as well as such other factors as cosmic radiation, atmospheric drag, and energetic solar radiation. On the one hand, relatively large impacts may result in penetration of the vehicle surface and subsequent destruction of important equipment, affecting the usefulness of the vehicle, while smaller impacts would result in an abrasion affecting the usefulness of lenses and photosensitive surface areas, etc.

It is therefore necessary to determine the probability of collisions with interplanetary particles as a function to time, and the effect of the individual collisions on the vehicle in order to determine design criteria for ARS. These requirements may be fulfilled by a measurement program involving high altitude rockets and satellite type vehicles, and direct laboratory studies of high speed impact interactions. Related studies that would support direct probing methods are also of interest in order to afford a higher degree of validity to the experimental results.

(d) Approach

The areas of investigation in this task may be broadly divided into rocket and satellite experiments and laboratory studies.

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(1) Determination of the influx of meteoric material by rocket experiments

This includes the design and construction of equipment and launching of rockets containing this equipment for the detection of meteoric material. The equipment for detecting meteoric material will operate on the principle of detecting the vibrational energy generated upon impact. This apparatus includes piezoelectric accelerometer, an amplifier, and a telemetering system with its associated ground-based receiver-recorder. Aero bee and/or Nike-Cajun rockets will be used to carry out the program. It is important that a statistically valid sample of meteoric material be obtained for final design of the ARS.

The program of research for direct rocket probing of interplanetary matter involves first the design and development of a basic piezoelectric accelerometer capable of measuring the spatial distribution and mass of interplanetary particles. Such equipment has been used by Prof. Bohn in 1949 and was used again during 1955. Hence, only minor develópement and calibration methods are required prior to construction of the basic unit. Such equipment is sensitive enough to detect particles of visual magnitude 25. Approximately ten to twenty detection units will be built on a semi-mass production basis. Approximately five to ten successful experimental firings from Holloman Air Force Base using Aerobee rockets are required prior to establishing a weighted statistical figure for the intensity and probability of a particle impact with a vehicle. About five successful firings at a high latitude would be required to establish the extent of a latitude dependence particularly by small meteoric particles.

(2) Design and development of equipment for detection of meteoric material for inclusion in the ARS.

It is expected that development work in the rocket phase of detection of meteoric material will aid greatly in the development of equipment of a similar nature to be included in the early oribiting and non-orbiting ARS test vehicles. It is important that the apparatus be designed with a high degree of reliability, yet be lightweight, and have a low power requirement.

(3) Theoretical and laboratory studies and high speed impact phenomena

Essential to the measurement of interplanetary matter is a knowledge of the relation of the intensity and frequency distribution of the accoustical energy generated by high speed meteoric impacts to the mass, the mass density, and the velocity of collision with the meteoric particle. Thereby, the surface erosion and the distribution function of meteoric material in space may be determined from the ARS measurements. Polished plate experiments on rockets that may be recovered will yield some information, but high speed impact measurements in the laboratory for the study of collisions of solids with gases and surfaces are required to support this subtask. In addition, optical and radio measurements of meteor influx and atmospheric interactions will also assist in the direct experimental studies.

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High speed impact studies of particles with surfaces are possible at this time only by a method using shaped charges, since only by this means have particle velocities comparable with meteor velocities been generated in a laboratory basis. The physics of high speed interactions is not well understood, and experimental measurements at velocities up to 50 km/sec are highly desirable. Even then, it is difficult to predict the degree of success of this technique, but this approach is presently available at relatively low cost. Because the energy density of the impacting reactions may be as much as a hundred times greater than previously observed, considerably different effects than theoretically predicted are to be expected.

(4) Theoretical studies

This subtask is concerned with the correlation and application of various data applicable to the problem of determining the hazard from interplanetary matter upon ARS. Where possible, information from shock tube studies, radio and optical meteoric studies, investigations of meteoric craters, deep see ocean sediments, microchemical analysis of rare gas constituents, etc., that contribute to the overall problem of the determination of the hazard from interplanetary matter will be considered. In this manner, the reliability of the information derived from the direct experimental program may be further evaluated.

The primary emphasis of the approach of the 4 subtasks, therefore, is the determination of the spatial distribution of interplanetary matter, the size distribution, and the mass density of this material, and thus with suitable laboratory studies to be able to predict the probability that meteoric material may penetrate a given thickness of satellite skin per unit time, and the rate of erosion per unit area for a surface exposed above the earth's atmosphere. An improved understanding of the physics of hypersonic interactions in the velocity range equivalent to an energy of 50 to 1000 electron volts is also of importance.

The rocket program for detection of meteoric particles would require approximately ten successful rocket flights up to altitudes as high as 150 km before sufficient data to make a satisfactory estimate of the rate of influx of interplanetary matter. It should be stressed that ten successful flights corresponds to a total measuring time of about a quarter of an hour above altitudes of 50 km. (Measurements below this altitude would be contaminated by terrestrial material). From considerations of the normal difficulties experienced in past experimental programs using high altitude rockets, probably instrumentation for fifteen rockets will be necessary. The estimated cost of development and construction of this instrument is 60M to 100M based on cost of 5M per instrumentation. The cost of rockets for this work based on 30M for a single Aerobee rocket would be 450M for 15 Aerobees. However, since the meteoric detection equipment may be used on a Nike-Cajun rocket system, also, the overall rocket cost is expected to be much lower than the

estimate using Aerobee because the Nike-Cajun system when it becomes available would cost less than half as much as an Aerobee. The fund requirements however, are based upon rocket requirements using Aerobees.

Upon availability of an ARS vehicle as a platform for the measurement of meteoric particles, a relatively large sampling time for making measurements of interplanetary matter will be available. It is therefore of importance that meteoric detection equipment be mounted on such an early test vehicle. Such equipment must be very reliable and capable of operation over a long period of time, while its weight should be kept to a minimum. The development of equipment for the ARS is estimated to cost 50M over a two-year period, while flight and rocket testing would involve an additional 40M.

The program on research on high speed impact phenomena will be based on studies using shaped charges, and also investigations of dynamic interactions of meteoroids in the atmosphere. The estimated cost of the initial phase of this work is 80M over a two-year period.

3. (a) T-39793 - Atmospheric Density Determination at Altitudes of Artifical Earth Satellites.

(b) This task will be accomplished through a combination of "in-house" and contractual effort. Current contracts in effect are as follows:

(1) AF 19(604)-1871 - University of Michigan
(2) AF 19(604)-1890 - University of Michigan

(c) The objective of this task is to obtain reliable values of atmospheric density, pressure and kinetic temperature between the altitudes of 200 to 400 miles.

Requirement and/or Justification

The primary objective of this task is to obtain reliable values of atmospheric density, pressure and kinetic temperature in the vicinity of 200 to 400 miles altitude, the altitude of a proposed satellite system. These data are needed in solving various problems on the design of the ARS vehicle. Some of these problems are:

1. What altitude must be maintained by a satellite vehicle of specified size and shape in order that the atmospheric drag be sufficiently small to permit a minimum specified life time of the satellite.

2. How does temperature rise on the skin of the satellite vehicle due to aerodynamic heating (friction between itself and the molecules of the atmosphere) vary with altitude below 400 miles altitude.

3. What is the minimum value of mass to cross-section area ratio of a satellite which will permit the required lifetime to be achieved at specific

orbiting altitudes. The present estimates of the magnitudes of these properties are quite uncertain. Pressure and desnity may be in error by factor of 100 or 1000 at 350 miles altitude because they are based on extrapolation of values at 100 miles and on unconfirmed theories. Extension of measurements to 200 miles or 250 miles altitude would greatly improve the reliability of extrapolation to 300 miles, while measurements at 300 miles would be even better.

The task involves the study and implementation of two basically different methods for obtaining the necessary data. The first method involves the direct measurement of the drag force on a sphere falling from great altitudes after its ejection from a rocket. This method is of special interest since it is the drag force on the satellite which ultimately determines its life Results of this measurement are free from effects of contamination from the rocket. The limitation of this method lies in the fact that the sphere must fall from an altitude of 10 to 20 percent higher than that for which the drag data are desired.

The second method for obtaining these data involves a selective ionization gauge for measuring number density of particular constituents as well as total number density. This method in principle may be used to the peak of rocket trajectory but is adversely affected by contamination from the mother rocket. Various outgassing and ejection techniques under study will minimize this limiation.

A secondary objective of this task is to develop the necessary techniques and devices for measuring pressure, temperature and density from ARS test vehicles. This phase depends in part upon the success of the primary objectives, although the conditions for outgassing are sufficiently different to materially simplify the accomplishment of this objective.

(d) Approach

At this writing, the task appears to involve eight steps.

(1) Feasibility study of two proposed methods for measuring the required parameters.

The feasibility of two methods for the measurement of atmospheric density, pressure and temperature are being explored. These methods are (1) an extension of the falling sphere experiment and (2) the ionization gauge experiment currently being employed up to altitudes of 75 to 100 miles.

The present falling sphere experiment involves the ejection of a sphere from a rocket at high altitudes, and the measurement of the drag force of the atmosphere on the sphere as it moves though space. (It may be ejected anytime after the end of rocket powered flight and hence will rise to a peak slightly lower than that of the rocket.

The sphere contains an accelerometer which measures drag acceleration as a function of time to 1% accuracy, independent of orientation. The sphere also contains a radio transmitter which relays the accelerometer signal to a ground recorder. The double integration of the total acceleration yields sphere altitude as a function of time to a reasonable accuracy for high angle flights. An independent complicated analytical reiteration method yields sphere velocity and altitude versus time independently. The determination of atmospheric density depends upon a knowledge of drag coefficient at the mach numbers and Reynold's numbers experienced by the sphere. These values of drag coefficient have been measured in ballistic ranges and hypersonic wind tunnels.

The present ionization gauge experiment involves the measurement of ion current from ionized air molecules on one or more chambers on the surface of a rocket. The knowledge of air pressures around conical surfaces with known orientation to the air stream leads to a value of ambient pressure and to temperature if the relative velocity of cone to air is known. This sytem requires some kind of tracking for high accuracy although integration of pressure and temperature values results in approximate altitudes.

Extending the sphere experiment to higher altitudes involves increasing the area to mass ratio of the sphere, shifting the range of the accelerometer to very low values (this essentially eliminates its use at higher accelerations, corresponding to lower altitudes). The system does not work at or near zenith since the velocity is too low (approaching zero for a verital flight) for drag to be measurable.

The extension of the ionization gauge method involves three main steps: (a) Adapting to rocket use existing ionization gauges designed for ver low pressures (Alpert type); (b) eliminating the effect of contamination of the measurement from rocket outgassing by housing the gauges in a separate thoroughly outgassed body which will be spring ejected from an evacuated cavity at high altitude; (c) Eliminating the uncertainty of molecular dissociation by making the gauge sensitive to only one or two specific molecular species through simple mass spectrometer techniques.

The feasibility study of the use of these methods at high altitudes is currently under way and involves a study of (a) the theoretical limitation (b) inherent sources and estimates of errors (c) engineering difficulties (d) space and weight requirements (e) estimated cost per flight. An analysis of these studies will determine which method has the better chance of success, but at present it appears that both should be tried. Perhaps both may be flown simultaneously in each rocket vehicle.

(2) Design and construction of preliminary models of equipment for one or both methods

This step of the task involves the design and construction of the equipment which is expected to be flown in the initial series of rocket

flights. This step may include wind tunnel tests or rocket flight tests of specific portions of the total instrumentation for the method, as well as the final packaging of at least two sets of the equipment for the rocket flights of each of the two methods.

(3) Initial rocket flights of the equipment for one or both methods

This step includes the field operation involved in preparing the equipment for actual rocket flight together with the necessary operation of the rocket flights for each method. The preparation for two flights is insurance against rocket or other failure during the first flight.

(4) Evaluation of flight performance and necessary redesign of equipment

This step involves the detailed study of the telemeter record of the flight to determine the performance of the various parts of the measuring equipment, as well as the transcription of recorded data to usable form for computation of the required atmospheric parameters. Deficiencies in the performance of the equipment detected by the record are then to be removed by suitable redesign. Because of the urgency of the program, major portions of the equipment should already have been constructed at this point for the series of data-gathering flights and it will be necessary to take the chance of having to modify some of the components at this stage of the task.

(5) Major series of data gathering rocket flights

This step of the task involves the flying of three to ten sets of instrumentation for density and or pressure measurements in special 300 mile altitude rockets presently being designed for AFCRC or in non-orbiting ARS Weapons System test vehicles or both. Contact will be made with the ARS Weapon System office to obtain space in these test vehicles. If the first three flights indicate sufficient self-consistency the balance of the data gathering flights can be cancelled.

The special 300 mile altitude rocket is a multi-stage system made up of existing rocket components, i.e., Cajun rockets and Nike boosters. An engineering study presently contracted for will result in engineering drawings for the necessary fins and coupling devices and nose cone necessary to combine the propulsion system into an atmospheric data gathering rocket system capable of carrying 40 lbs. of instrumentation to 200 - 300 miles. Upon completion of this engineering study, engineering drawings will be available from which the necessary parts and propulsion units may be built and purchased at an estimated cost of $20,000 per rocket system.

(6) Analysis of data and preparation of revised atmospheric model

This step of the task involves the reading of telemeter records, the computation of the values of the atmospheric parameters, and

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the compilation of these data into consistent atmospheric models. This step is not necessarily limited to follow step (5) chronologically, but will follow each rocket flight from which usable data results.

(7) Repackaging of equipment for test satellite vehicles

This step involves the electrical mechanical redesign of the equipment used in the rocket firings of step (5) or planned in steps (1) and (2) to make that equipment suitable for gathering desired atmospheric data from ARS test vehicle.

(8) Installation and flight of density and pressure measuring equipment in satellite vehicle

This phase involves the field operation of a program for measuring atmospheric density and pressure at orbital altitudes of satellite test vehicles, and would be followed by a reapplication of step (6).

4. (a) T-39794 - Thermal Radiation Program for ARS

(b) This task will be accomplished through a combination of "in-house" and contractual effort. Present contractor is the University of Colorado under Contract AF 19(604)-1899. Additional contracts are contemplated.

(c) The objective of this task is to measure the intensity of irradiant heat sources above the atmosphere.

The radiation environment is one of the external conditions which may grievously affect the period during which information can be obtained from an oribiting satellite.

To be operational, the design of the satellite must be engineered so as to maintain within pre-determined limits the temperatures of vital communication components, such as electronic units, batteries, etc. If and when nuclear sources are used for power, then the excess energy must be radiated away from an external heat exchanger; its design requires a knowledge of the radiation exchange environment.

The temperature of a satellite in orbit at given times and places can be calculated. Required for these calculations are a knowledgeof the interstellar heat sink into which it is radiating energy -- thus cooling it -- and a knowledge of the intensities of the thermal fluxes which tend to warm it. Estimates of the equilibrium temperature of the satellite can be verified only by measurements within the orbiting satellite. Under the worst condition the

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temperature within the communication equipment may cause it to fail before any information is received. A slightly more favorable but undesirable condition would be a premature failure of communcation. (Thus, should the absorptivity--equal to emissivity--of the skin of the satellite change while in orbit, the equilibrium temperature of the satellite might differ drastically from that calculated on the basis of design specifications.)

The objective of this task is, then, the development and testing of devices adequate for the measurement of the three irradiant sources--direct solar energy, solar energy reflected jointly from earth and atmosphere (I.E., albedo) and earth emissivity (in the infrared)--and the flux from a satellite into interstellar space.

It is proposed that flux measuring devices should be installed on the earliest test vehicles so that flux measurements can be obtained so long as communication with the satellite is continued. Should communications then cease, and should the thermal, flux measurements seriously disagree with the values in the design calculations, at least one source of possible trouble should be identified.

During the development and testing of the devices for measuring the three sorts of radiation, balloon and rockets equipped with these devices will be flown. As scientific by-products of the testing program, some confirmation of current estimates of the intensities of the three sources will be obtained. Our present information on the radiation environment is next summarized.

Reliability of Present Estimates of the Solar Constant and <u>the Albedo and Infrared Emission of Earth Plus Atmosphere</u>

a) The solar constant is believed to lie between 1.946 and 2.05 gram calories centimeter $^{-2}$ minute $^{-1}$, a deviation of 3% from the mean of 2.0 gm cal cm^{-2} min^{-1}(1,396 watts meter $^{-2}$).

b) For this discussion, the term albedo applies to the solar radiation reflected directly from the earth's surface and scattered and reflected from the atmosphere with its content of clouds. From point to point in the orbit of a satellite with orbital distances as now stated the albedo will be highly variable. Deviations may be expected of at least plus or minus 20 - 30 per cent from the mean value of the albedo which may be taken as lying between 36-56 per cent (I.E. approximately 36-56 per cent of the solar constant is diffusely reflected or scattered back from the earth).

c) The infrared emission of the earth may be estimated by theory. Current estimates for the various zones of latitude obtained by deduction may well be in error by 20 to 50 per cent; on the average energy to about 32 per cent of the solar constant is diffusely emitted as infrared radiation from the unit consisting of earth and atmosphere.

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(d) Approach

I. Introduction

The following subtasks are foreseen:

(1) The design, development, testing and calibration of devices for the measurement of radiation of the following kinds.

(a) Total radiation from 0.27 to 2.7 microns (By "total" is a single detector which integrates the energy in the specific spectral region non-selectively -- i.e., recording to heating value, not by number of photons.)

(b) Total radiation from 4 to 20 microns.

(2) The design, development, testing and calibration of temperature sensors.

(3) Considered, but at present neither planned, funded nor contracted, would be the study of the temperature of a model of the satellite in a simulated radiation environment in a test chamber in the laboratory, or balloon-borne to an altitude where the air pressure approximates ten millibars (about 100,000 feet).

(4) A subtask within scope of this task, but deserving separate discussion will result in new techniques, design experience, and data important to ARS as vehicles for reconnaissance. This subtask is amplified specifically in Section II, Activities in "(4) Activities -Infrared Background Studies".

II. Activities

(1) Activities - General

The statement of the task may be amplified by noting that the satellite in its orbit will be warmed by energy from sun and from earth and cooled by radiating energy outward. Its native temperature will vary between upper and lower limits determined by intrinsic qualities (skin absorptivity and emissivity for various parts of the spectrum from ultraviolet through far ultraviolet and the heat capacity), and the trajectory (portion of period of orbit when irradiated by sun plus earth, or in the eclipse shadow of earth wher irradiated by earth emission only; and the distances from earth at apogee and perigee, and whether these occur in sunlight or in shadow.

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Further, it is probably that various other sources of heat may be added as the development of the satellite proceeds from the preliminary phases of design, construction, and test to the more sophisticated, complex designs. For example, possibly a fission reactor may serve as source of power for attitude control and for electronic equipment. The introduction of such a heat source will complicate the engineering considerations because the efficiency of the removal of the excess heat will depend on the thermal environment of the heat exchangers.

(2) <u>Activities --- Model Study</u>

A possible activity which, as noted above, has not passed beyond the discussion stage, is that of the M$_o$del Study for obtaining approximate values of the equilibrium temperatures under working conditions a simulated satellite might be studied. By appropriate choice of the model, which would incorporate such devices as quartz windows inserted into the sphere, probably supplemented by isolated heat - detecting receivers, it is probably that significant information could be obtained. Such a model could be tested in a "Stratospheric Chamber" equipped with appropriate radiant heat sources. Or, the model satellite could be carried by balloon to high altitudes ---about 100,000 feet where pressures approximating 8 mm Hg. would minimize convective cooling.

In such studies numerous experimental details would have to be carefully watched. For the receivers consideration would have to be given to the absorption of radiation by the receiving surfaces ("blackness" to different spectral regions to the "color temperature" of the radiant flux), also to the conditions for the conductive removal of heat, and to the necessary precautions against convective cooling, since in the satellite at orbital altittudes there would be no convective cooling.

Departures from anticipated temperature by the satellite in its early history would be reason to look for unique influence -- heating by collision with meteoric matter, shortwave radiation with more than the expected intensity of gamma radiation.

Such a model might lend itself to experimental work in the design of a satellite to be powered by a fission device.

(3) <u>Activities</u> -- <u>Design and development of the temperature and radiation sensing equipment</u>

It is recognized that measuring the temperature of the skin and of the important points within the satellite in order to confirm the adequacy of the design is primarily the concern of the contractors. However, the themal flux sensors and the temperature sensors both will most likely be built around thermistors, hence, for reasons of design efficiency they would be parts of a common system. All thermal flux devices have high temperature coefficients, and the design will require a reference standard for absolute temperature determination.

It has been noted the type of thermal flux detector used should be "total" and "non-selective." As distinguished from photo-conductive detectors, the preferred type would be the "temperature" detector, i.e., the absorbed energy is measured by temperature change using a thermocouple or a thermister or equivalent.

Hence, the development and testing (including calibration) of the radiation sensors involves the use of the same accessory electronic equipment for imparting information to the telemetering system as would be used when thermistors are employed for obtaining temperature data within the satellite. A minor activity from the viewpoint of both man-hours and dollar costs, is therefore involved adding the responsibility for development, testing and calibration of the temperature sensing devices to the identical responsibilities for the devices for measuring thermal flux.

Timely and detailed reports of progress on this task will be provided so that designs of the temperature sensors and accessory electronic equipment will be available to the prime contractor for his use in instrumenting early test vehicles.

Approximately six months have passed since Contract AF 19(604)-1899 for $40,000 was awarded to the University of Colorado for work on this task. Relatively good progress has been made in the design of compact lightweight transistorized thermal flux detectors available soon for testing in high altitude balloon flights. However, for quantitative thermal flux measurements one accepted technique is alternately to expose the radiation sensor to the thermal flux to be measured and then to view a reference standard or flux (a black-body) determined by its absolute temperature. It is the development and testing of these assemblies of components which will demand the major effort.

(4) <u>Activities -- Infrared Background Studies</u>

In reconnaissance "vision" is involved. With the eye as the detector, the significant bandwidths used in vision are 0.4 to 0.7 microns. "Vision" in the ultraviolet involves a detector in the range 0.2 - 0.4 microns. In the infrared, "vision" comprises wavelengths from 0.7 to 25 microns. It is obvious that "vision" is the discrimination of an object viewed with a given bandwidth against a "background" also "seen" by the detector. Further, radiation scattered toward the detector by material between the object and the detector obscures vision (cf. visibility through fog).

Reconnaissance by use of far infrared introduces another factor not unlike the scattering effect in visibility through fog. That is, the radiation from the object and its background will be veiled by the energy emitt[ed] by the strata of atmosphere between object and detector. In the region from

4 to 24 microns knowledge of temperatures, spectral emissivities (equal absorptions) of the specific gases of the atmosphere are required. Much is known about the pressure dependence of the absorption but easy calculation is not yet possible.

Both experimental and theoretical phases under this infrared background study are planned:

Experimental:

(1) The design and construction of a far-infrared spectrometer to be borne aloft by balloon capable of measuring the terrestrial thermal flux, spectrally resolved from 4 to 24 microns, etc. The work to be contracted.

(2) Design and construction of balloon borne equipment to measure attenuation of the infrared solar flux in the region of 0.8 to 9 microns at various altitudes from 5,000 to 100,000 feet, with sun at low altitudes to increase the path length through the atmosphere. The work to be contracted.

Theoretical:

(3) The thermal emission from model atmosphere corresponding as closely as possible to the terrestrial atmosphere will be calculated using the latest available and suitable modified laboratory transmission functions. The emission will be computed for various heights to be later specified in the atmosphere. The work to be contracted.

Possible contractors, and the possible Principal Investigators are:

Johns Hopkins University, Prof. John F. Strong
University of Utah, Prof. J. V. Hales (with Prof. W. Elsasser, Consultant, Scripps Institute of Oceanography)
Aerotronics, Glendale, Calif., Dr. Gilbert N. Plass
University of Colorado, Prof. W. S. Rense
University of Denver, Mr. David Murcray
Ball Bros. Research Institute, Dr. David Stacey

(5) <u>Activities - By-Products Directly Applicable to ARS</u>

The main groups of by-products of the program of work on the Thermal Radiation program may be anticipated for ARS. One group is the reduction in the uncertainty in the three sorts of radiation intensities

noted as important -- the solar constant, the albedo associated with various physiographic features of the earth (both the earth surfaces itself and cloud cover meteorologically and physiographically determined), and the infrared emission. During the testing of the thermal radiation sensors during ballon and rocket flights data will necessarily accumulate which may reduce the error in present estimates of the intensity of these radiations.

The studies undertaken during the assessment of the radiation environment of the satellite will produce new knowledge about the energetics of the planet earth and its atmosphere. The new knowledge, as well as the sensors and accessory equipment from the task on thermal environment, will be of advantage to the contemplated Weather Reconnaissance Project in the event that is undertaken. Hard and fast lines cannot be drawn separating the work on thermal flux sensors from the work on the sensors which could be used on the Weather Reconnaissance Project. To the extent that work on this task (T-39794) advances the work on the Weather Reconnaissance Project, this later progress may be considered a by-product. However, under the Weather Reconnaissance Project would be required the production of sensors specifically adapted for installation in aircraft, and following the flights, reduction and study of the data. Such work is not contemplated in the budget proposed for this task.

5. (a) Task 39795 - Rocket and Instrumentation Support

(b) This task will be accomplished through a combination of "in-house and contractual effort. The type of effort required by this task is being carried on by AFCRC under GRD P-7659. In P-7659 several contractors have been used and have attained a competence in their respective areas (See Approach) In view of this competence, many of the same contractors will be used to accomplish the objectives of this task. Contemplated contractors include:

1.) Aerojet - General Corporation
2.) Wentworth Institute
3.) Oklahoma A and M
4.) New Mexico A and M

(c) The task objective is to instrument and launch research rockets in support of the objectives of the other tasks in this project.

Requirement and/or Justification

The requirement for this task is delineated in the approach of each of the other tasks of the project.

(d) Approach

[redacted]

The instrumentation and launching of research rockets require

(1) The provision of vehicles and launch facilities suitable to each experiment.

(2) The instrumentation of the nose cone. This effort may vary from simple attachment to the rocket to adaption of the experimental equipment to the vehicle and its support instrumentation.

(3) Collateral instrumentation for tracking, telemetering, range safety, data recording, parachute recovery, special sequencing and command of experiments, orientation of sensing devices (biaxial pointing control) and others.

(4) The provision of suitable ground data recording equipment.

Techniques and procedures have been established under GRD P-7659 to accomplish the desired results in the above areas of effort. In order to meet the requirements of the other tasks of this project, the same techniques and procedures will be followed under this task. In particular, the same contractors and facilities will be used, where applicable, and coordir tion with necessary test facilities will be carried out in the same manner as under P-7659.

In order to efficiently and effectively make use of system test vehicles close coordination will be established with the prime contractor. Such liaison is necessary to adapt the experiment to system test vehicles from the standpoint of size, weight, available telemeter, power, etc.

d. Other Information

Not applicable

e. Background History

System Requirement No. 5 dated 17 October 1955 subsequent letter directive from WDD placed on AFCRC the responsibility of providing environmental data effecting the design and test of ARS vehicles. Studies by the Geophysics Research Directorate, AFCRC, the design study contractors and the ARS Weapons System office determined that in certain areas the state of the art was such that additional data would be required to satisfy the design requirements of ARS. In December 1955 and January 1956 Tasks 76971, 76972, 76973 and 76974 under Project 1115 were prepared by Geophysics Research Directorate, Air Force Cambridge Research Center. These tasks were, with certain exception approved by WDD 3 July 1956. This project constitutes a rewrite of these tasks under Project 1764 in support of WS 117-L.

[redacted]

[redacted]

f. Future Plans

This project is for the specific purpose of providing environmental design data for the Advanced Reconnaissance System, therefore, the various task and subtasks will be terminated, with concurrence from the WS 117L WSPO, when it is apparent that sufficient data has been obtained in a particular field to satisfy design requirements or to determine a no hazard condition to the ARS vehicle and operational subsystems.

Conversely close coordination will be maintained with the WSPO and prime contractor so that new tasks can be timely instituted to meet requirements generated by the introduction of new design conception.

g. References

ARDC System Requirement No. 5 dated 17 October 1955

Secret Letter WDD to AFCRC sub: Support of Advanced Reconnaissance System (U) dated 23 December 1955.

WS 117L Advanced Reconnaissance System Development Plan dated 2 April 1956.

ARDC System Development Directive Advanced Reconnaissance System dated 17 August 1956.

SIGNED

MURRAY ZELIKOFF
Project Scientist
Photochemistry Laboratory

SIGNED

MILTON GREENBERG
Director
Geophysics Research Directorate

SIGNED

GEORGE P. JONES, JR.
Lt. Colonel USAF
Ballistic Missile Liaison Officer
Air Force Cambridge Research Center

[redacted]

FREDERIC C. E. ODER
Colonel, USAF
Assistant for WS117L

[redacted]

1. Special Annex for Mission Support Funds

2. Reports Control Symbol

Page of page

3. DATE: 2 April 1957

4. TITLE 5. Initial 6. NUMBER - 1764

(UNCLASSIFIED TITLE) Geophysical Environment for ARS, WS 117L

SHORT TITLE: ARS Environment

1a. $4255. of P-690-02 funds will be required in the performance of task 39721 in FY 57.

(1)	6 trips to Los Angeles and Palo Alto, Calif. at $400.	$2400.
(2)	3 trips to Chicago, Ill. at $125.	375.
(3)	12 trips to New York, N.Y. at $40.	480.
(4)	Miscellaneous travel	1000.
		$4255.

b. This travel will be essentially to monitor contracts and coordinate with other Centers. The requirements for FY 57 will continue through FY 58 and FY 59.

c. In FY 58 six (6) additional trips to HADC at $400. each will be required to arrange rocket tests.

d. In FY 59 twelve (12) additional trips to HADC or Patrick AFB at $400. each will be required for rocket tests on apparatus.

e. Therefore, for FY 58 P-690-02 $6655.

FY 59 $9055.

2a. $8000. of P-690-02 funds will be required in the performance of T-39792 during FY 57. Specifically it is contemplated.

(1)	12 trips to Holloman Air Development Center, N.M. at $450. each	$5400.
(2)	4 trips to San Francisco, Los Angeles area, Calif. at $400. each	1600.
(3)	3 trips to Philadelphia, Pa. at $50. each	150.
(4)	Miscellaneous travel; $850	850.
	TOTAL	$8000.

[redacted]

b. Travel to Holloman Air Development Center will be performed in carrying out high altitude rocket experiments. Each rocket experiments. Each rocket firing requires at least two (2) personnel for a period of a week to ten (10) days.

c. It is contemplated that some of the shaped-charge experiments may be performed by the Poulter Laboratories in the San Francisco area. Research on High Speed Impact Phenomena will be coordinated with Rand Corporation in Santa Monica. Temple University in Philadelphia has developed acoustical apparatus for the detection of meteoric impacts.

d. The travel requirements for this task thru FY 59 will probably remain at about $8000. per year.

3a. $5970. of P-690-02 funds will be required in the performance of Task T-39793 in FY 57.

(1)	2 trips to Los Angeles, Calif. at $400. each	$800.
(2)	4 trips to Ann Arbor, Mich. at $125. each	500.
(3)	8 trips to HADC, N.M. at $400. each	3200.
(4)	2 trips to Chicago, Ill. at $125. each	250.
(5)	8 trips to New York area at $40. each	320.
(6)	Miscellaneous travel	1000.
	Total	$6000 00

b. This travel will be essentially to monitor contracts and coordinate with other Centers. The requirement for FY 57 will continue through FY 58 and FY 59.

c. In FY 58, 7 additional trips to HADC at $400. and 2 additional trips to Los Angeles at $400. will be required to participate in rocket data gathering flights and monitoring contracts.

d. In FY 59, 4 additional trips to HADC at $400. will be required to participate in rocket data gathering launchings.

3. In FY 60 travel will be required as follows:

(1)	2 trips to Los Angeles at $400. each	$800.
(2)	2 trips to Chicago at $125. each	250.
(3)	3 trips to New York at $40. each	120.
(4)	Miscellaneous travel	300.
	Total	$1470.

Therefore,	P690-02
FY 58	9570
FY 59	7570
FY 60	1470

[redacted]

[redacted]

4. $3,225.00 of P-690-02 funds will be required in the performance of task T-39794 during FY 57. Specifically we contemplate:

(1)	3 trips to Los Angeles, California at $400. each	$1200.
(2)	4 trips to Baltimore, Maryland at $60. each	240.
(3)	3 trips to Chicago, Illinois at $125. each	375.
(4)	2 trips to Holloman ADC, N.M. at $400. each	800.
(5)	2 trips to WADC, Dayton, Ohio at $100. each	200.
(6)	2 trips to RADC, Rome, N.Y. at $55. each	110.
(7)	Miscellaneous travel: $300.	300.
		$3225.

a and b Travel to the Los Angeles area and to the Baltimore area is predicted on the assumption that the contractors, at least for the vehicles for scientific measurements, will be in either or both areas. Also, at least one visit to WDD is contemplated.

c. Travel to the Chicago area is included on the assumption that contractor for the temperature and radiative transfer sensors might quite probably be in Chicago or equally distant from Boston, Mass.

d. Travel to Holloman ADC looks forward to preliminary testing of instrumentation in the upper atmosphere by balloons or rockets, or both.

e. Travel to WADC and to RADC will be required to coordinate the various Center efforts. It is possible that the number listed is a minimum and that more will be required.

f. Miscellaneous travel to discuss specific problems with experts at various Universities will be required.

g. After FY 57 we anticipate that because of the increased activity the travel requirement will be increased to an average $4,500. per year.

h. An annual average of $1000. of P-690-03 funds will be required to transportation of instrumentation units during FY 58 and FY 59.

5a. $14,000 of P690-02 funds will be required in the performance of task T-39795 during FY 58.

(1)	12 trips to HADC at $500. each	$6000.
(2)	4 trips to Los Angeles, Calif. at $400.	1600.
(3)	8 trips to Palo Alto, Calif. at $450. each	3600.
(4)	4 trips to Patrick AFB, Fla. at $200. each	800.
(5)	Miscellaneous	2000.
	Total	$14,000.

[redacted]

[redacted]

[redacted]

b. Travel to HADC will be performed to participate in launching of high altitude rockets.

c. Travel to Los Angeles will be performed for coordination of program with WSPO.

d. Travel to Palo Alto will be performed for liaison in obtaining technical information on use of system test vehicles.

e. Travel to Patrick AFB will be performed for coordination and participation in launching of system test vehicles.

f. The travel requirements in this task are expected to remain essentially the same for FY 59 and FY 60.

[redacted]

5-2

[redacted]

R & D SCHEDUL[redacted]

☐ SYSTEM ☒ PROJECT ☐ TASK ☐ OTHER

2. REPORTS CONTROL SYMBOL

3. DATE 2 April 1957

4. TITLE (UNCLASSIFIED TITLE) Geophysical Environment Data for ARS, WS 117L
Short Title: ARS Environment

5. INITIAL ☒ CHANGE

6. NUMBER 1764

SCHEDULE		CALENDAR YEARS																																									
TITLE	PROJECT OR TASK NR	1955						1956												1957								1958				1959				1960				TO COMPL			
		J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
ARS Environment	1764													1			2				3			4				6			7			9	5				11				
																												8							10								
Solar U.V. and X-Ray	39791																																										
Intensity Measurement								3			4												6				7	7	7	7					11								
Sputtering																					3		4					6							11								
Interplanatary Matter & Met.	39792																																										
Rocket-Meteor Impact Studies														4					5	7		7	7			7	5	7	7	7	5	4			5								
ARS Meteor Detecting Studies																		4								7	5	8			5				5				11				
High Speed Impact Phenomena														3					5								5				5				5								
Theoretical Studies														3					5								5				5				5								
Satellite Altitude Density	39793																																										
In-House Studies														3	10											10		10		10				10	10								
Evaluation of Two Methods														3			2																										
Instrumentation & Rocket Test																						4						7	7	7	7												
ARS Test Vehicle Program																								4					7	7													
Therm RAD for ARS	39794																																										
Temperature Sensors											4			5			5					6	7								7	9	9	9	11								
Radiation Sensors											4			5			5	6		7				7							7	9	9	9	11								
Background Studies																																											
Theoretical																								4		55		5	5		5			11									
Experimental																								4		56		7	7		7	9	9	10	11								
Rocket Support	39795																			7		7	7			77		7	7	7	7												

Schedule Key:

1 - Let Study Contract
2 - Termination and Tech Rept (Study Contract)
3 - Begin In-house Studies
4 - Development Contract Awarded
5 - Technical Report
6 - Apparatus Tested in Lab
7 - Test & Data Gathering Flights
8 - Satellite Instrumentation Complete
9 - Measurement on ARS Flight
10 - Analysis of Data
11 - Final Report

ARDC FORM 103 PREVIOUS EDITIONS OF THIS FORM ARE OBSOLETE [redacted] 2WD-57-01140

1. R & D MANPOWER ANNEX	2. REPORTS CONTROL SYMBOL
☐ SYSTEM ☒ PROJECT ☐ TASK ☐ OTHER	PAGE 26 OF PAGES
	3. DATE 2 April 1957

4. UNCLASSIFIED TITLE	5.	6. NUMBER
Geophysical Environment Data for ARS, WS 117L Short Title: ARS Environment	INITIAL ☒ CHANGE	1764

7. ORG COMP CODE	8. ORGANIZATION TITLE	9. TYPE ORG	10. ACTUAL MAN-QTRS LAST QTR	11. PROJECTED DIRECT MAN-YEARS						
				FY 1957		FY 1958		FY 1959	FY 19 60	TO COMPL
				AVAL	RQRD	AVAL	RQRD	RQRD	RQRD	RQRD
GRD	Geophysics Research Directorate AFCRC	R	4.5	5.0	24.5	5.0	29.0	32.0	26.0	
	TOTAL		4.5	5.0	24.5	5.0	29.0	32.0	26.0	
	Total Manpower Dollars		7,938	36,400	178,360	36,400	211,120	232,960	189,280	

Manpower Justification Attached:

[redacted]

1\. **R & D MANPOWER ANNEX**

☐ SYSTEM ☒ PROJECT ☐ TASK ☐ OTHER

2\. REPORTS CONTROL SYMBOL

PAGE OF PAGES

3\. DATE: 2 April 1957

4\. UNCLASSIFIED TITLE: Geophysical Environment Data for ARS, WS 117L
Short Title: ARS Environment

5\. INITIAL ☒ CHANGE ☐

6\. NUMBER: 1764

7. ORG COMP CODE	8. ORGANIZATION TITLE	9. TYPE ORG	10. ACTUAL MAN-QTRS LAST QTR	11. PROJECTED DIRECT MAN-YEARS: FY 19 57 AVAL	FY 19 57 RQRD	FY 1958 AVAL	FY 1958 RQRD	FY 1959 RQRD	FY 1960 RQRD	TO COMPL RQRD

1\. Task 39791 will require the services of a total of eight physicists (civilian or military) of qualifications equaling those of GS-12 or higher. Two of these are now available, both GS-13, and therefore six additional physicistswill be required, beginning immediately and extending through the duration of the project.

2\. The manpower requirements on Task 39792 for measuring the influx of interplanetary matter is estimated on the basis that three physicists and one electronic engineer (GS-11 to GS-13) will be required during the initial phase of the program during the remainder of FY 57. As test firing increases in FY 58 and FY 59 an additional mathematician (GS-11) will be required in the analysis of this data. This research team will be reduced to three (3) through the completion of the task.
This group will be responsible for the overall planning of the program and the experimental rocket and satellite program. The application of significant experimental laboratory data, and the establishment of significant experimental laboratory data, and the establishment of theoretical design criteria will be made up by this group also. The preparation and prosecution of general scientific plans, coordination, monitoring of contractual research and development, the preparation of summary and technical reports will be handled by this team. It is believed that the scope of the problem involving acoustics, electronics collision theory, meteor physics and other basic studies should be handled by a team; with a minimum size of at least five (5) people. At this time, the magnitude of this program may not be determined until the first phase of the research has been completed.

3. Manpower to perform research on Task 39793 will be divided into the following listed three (3) experimental teams:

a. Falling-Sphere Density Experiment Team

This team will consist of one task scientist (GS-12), one physicist (GS-11), and one engineer (GS-9)

b. Pressure Gauge Density Experiment Team

This team will consist of one deputy task scientist (GS-12), one physicist (GS-11), and one engineer (GS-9).

c. Data Reduction Team

This team will consist of one secretary (GS-3), and one computer (GS-9).

4. Responsibility of the 3 experimental teams will be as follows:

a. Falling-Sphere Density Team

(1) The responsibility of the Falling-Sphere Density Team will be to modify the existing Falling-Sphere Density Measuring Technique and scientifically develop, test and launch a modified instrumentation for density measurement at altitudes up to 500 Km.

(2) The responsibility of the task scientist is to plan and direct the over-all task program. In addition, he will directly administer the program of the Falling-Sphere team. He will consult with and advise the physicist and engineer in the theoretical study, design, development, laboratory testing, and contractual procurement of the flight model instrumentation; and will serve as Field Director at experimental test grounds.

(3) The physicist will be responsible for carrying out the team program of theoretical work on the applied and background research pertaining to the Falling-Sphere Density Experiment. He will be concerned with the evaluation of the theoretical aspects of the experiment, and all experimental progress in related fields of research. He will consult with, advise and assist the engineer in the laboratory experimental phases of the team program, and the electronic and mechanical design of instrumentation. He will be responsible for the preparation of scientific reports and papers as required in the experimental program.

(4) The engineer will be responsible for the team laboratory experimental program, the electronic and mechanical design and construction of instrumentation. He will initiate procurement of instrumentation. He will

initiate procurement of and will monitor a contractor construction contract to build the final instrumentation for rocket installation. He will serve as field engineer during proving ground experimental tests.

5. Pressure Gauge Density Experiment Team

a. The responsibility of the Pressure Gauge Density Team will, in consideration of present methods limited to altitudes of about 130 km, scientifically plan, develop, test, and launch a rocket borne pressure gauge instrumentation for density measurement at altitudes up to 500 km.

b. The responsibility of the deputy task scientist will be to plan, direct and administer the program of the team. He will consult with and advise the physicist and engineer in theoretical study, design, development, laboratory testing, contractual procurement of the flight model instrumentation and will serve as Field Director at experimental test grounds.

c. The Physicist will be responsible for carrying out the team program of theoretical work on applied and background research pertaining to the Pressure Gauge Density Experiment. He will be concerned with the evaluation of the theoretical aspects of the experiment, and all experimental progress in related fields of research. He will consult with advise and assist the engineer in the laboratory experimental phases of the team program and in the electronic and mechanical design of the instrumentation. He will be responsible for the preparation of scientific reports and papers, as required in the experimental program.

d. The Engineer will be responsible for the ream laboratory experimental program, the electronic and mechanical design and construction of instrumentation. He will initiate procurement of, and will monitor a contractor construction contract to build the final instrumentation for rocket installation. He will serve as field engineer during proving ground experimental tests.

6. Data Reduction Team - The responsibility of the Data Reduction Team will be to reduce telemetered, photographic, and other transmitted data that may be supplied from airborne density instrumentation; and to present this data in useful form for geophysical interpretation.

7. The Task 39794 Planning and Supervision will be under the direction of a Task Scientist. Throughout the period of the task, he will be responsible for the preparation and prosecution of the general scientific plans and for the coordination of work of the contributing agencies of the entire program. He will be responsible for all the phases of the program, including selection of contractor, approval of proposals, supervision of both contractual

and in-house efforts contributing to design, fabrication, test, calibration and data reduction and interpretation -- in short, the integration of the results of the contract program and the in-house programs. The Task Scientist is currently available.

8. a. The manpower requirements for T-39795 for Rocket and Instrumentation Support are estimated on the basis that four Research Engineers, (GS-11 to GS-13) will be required during FY 57 to accomplish instrumentation for the required program. During FY 58 an additional two Research Engineers will be required to absorb the load of frequent field trips to rocket launch sites and to maintain the heavy schedule of rocket preparation and firings. In FY 59 two additional Research Engineers will be required to conduct liaison on instrumentation of orbiting and non-orbiting test vehicles.

b. This group will be responsible for the instrumentation of all rocket experiments in the program for coordination with launch sites, for collection and recording of data from rocket flighs and for liaison and planning with prime contractor in use of system test vehicles.

SF 42 [redacted]

1. R & D CONTRACT FUNDS ANNEX

☐ SYSTEM ☒ PROJECT ☐ TASK ☐ OTHER

2. REPORTS CONTROL SYMBOL

PAGE 31 OF 32 PAGES

3. DATE: 2 April 1957

4. TITLE
(UNCLASSIFIED TITLE) Geophysical Environment Data for ARS, WS 117L
(Short Title) ARS Environment

5. INITIAL ☒ CHANGE ☐

6. NUMBER: 1764

7. ITEM	8. PROJ OR TASK NR	9. END ITEM CAT	10. CONTRACT NUMBER	11. BPSN	12. PREV YRS 600	OTHER	13. FY 57 600	OTHER	14. FY 58 600	OTHER	15. FY 59 600	OTHER	16. FY 60 600	OTHER	17. TO COMPL 600	OTHER
ARS Environment	1764	R&E	Various	2-117	160M		422M		1000M		1410M		425M			
	P-100 Funds:					6M				950M		470M				
	P-200 Funds:											50M				
	Sub-Totals:		P-600		160M		422M		1000M		1410M		425M			
			P-100			6M				950M		470M				
			P-200									50M				
TOTAL					160M	6M	422M	0M	1000M	950M	1410M	520M	425M			

PREVIOUS EDITIONS OF THIS FORM ARE OB[redacted]

249-57-01140

59 [redacted]

2. REPORTS CONTROL SYMBOL

PAGE 32 OF 32 PAGES

R & D COST ESTIMATE RECAPITULATION

☐ SYSTEM ☒ PROJECT ☐ TASK ☐ OTHER

3. DATE: 2 April 1957

4. UNCLASSIFIED TITLE: Geophysical Environment Data for ARS, WS 117L
Short Title: ARS Environment

5. INITIAL ☒ CHANGE ☐

6. NUMBER: 1764

ITEM		A. PREVIOUS YEARS 600	A. PREVIOUS YEARS OTHER	B. FISCAL YEAR 57 600	B. FISCAL YEAR 57 OTHER	C. FISCAL YEAR 58 600	C. FISCAL YEAR 58 OTHER	D. FISCAL YEAR 59 600	D. FISCAL YEAR 59 OTHER	E. TO COMPLETE 600	E. TO COMPLETE OTHER
7. CONTRACT	A. TOTAL	160M	6M	422M		1000M	950M	1410M	520M	425M	0
	B. AVAILABLE	160M	6M	422M							
	C. NEW REQ					1000M	950M	1410M	520M	425M	0
8. MATERIEL	A. TOTAL										
	B. AVAILABLE										
	C. NEW REQ										
9. FACILITIES											
10. MANPOWER		7.9M		36.4M		178.4M		36.4M		422.2M	
11. TRAINING		N/A									
12. TEST ITEMS		N/A									
13. TEST SUPPORT AIRCRAFT		N/A									
14. SUBTOTAL		160M	6M	422M		1000M	950M	1410M	520M	425M	0
15. TOTAL		173.9M		458.4M		2128.4M		1966.4M		847.2M	

ARDC FORM 116 PREVIOUS EDITIONS OF THIS FORM ARE OBSOLETE. 32 [redacted] TAB-57-01140